Fume Hood Exhaust Stack Design: Dilution Criterion

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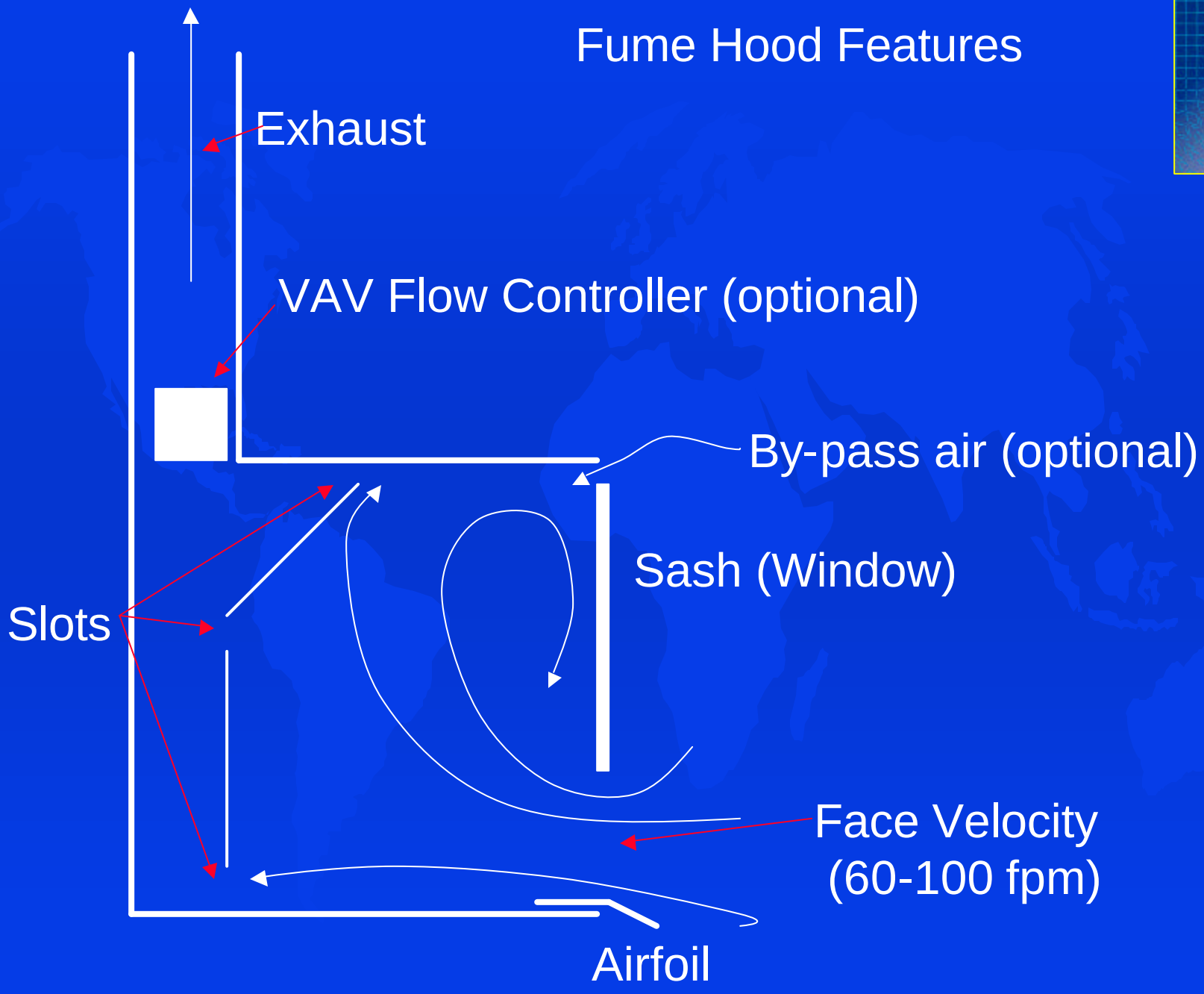
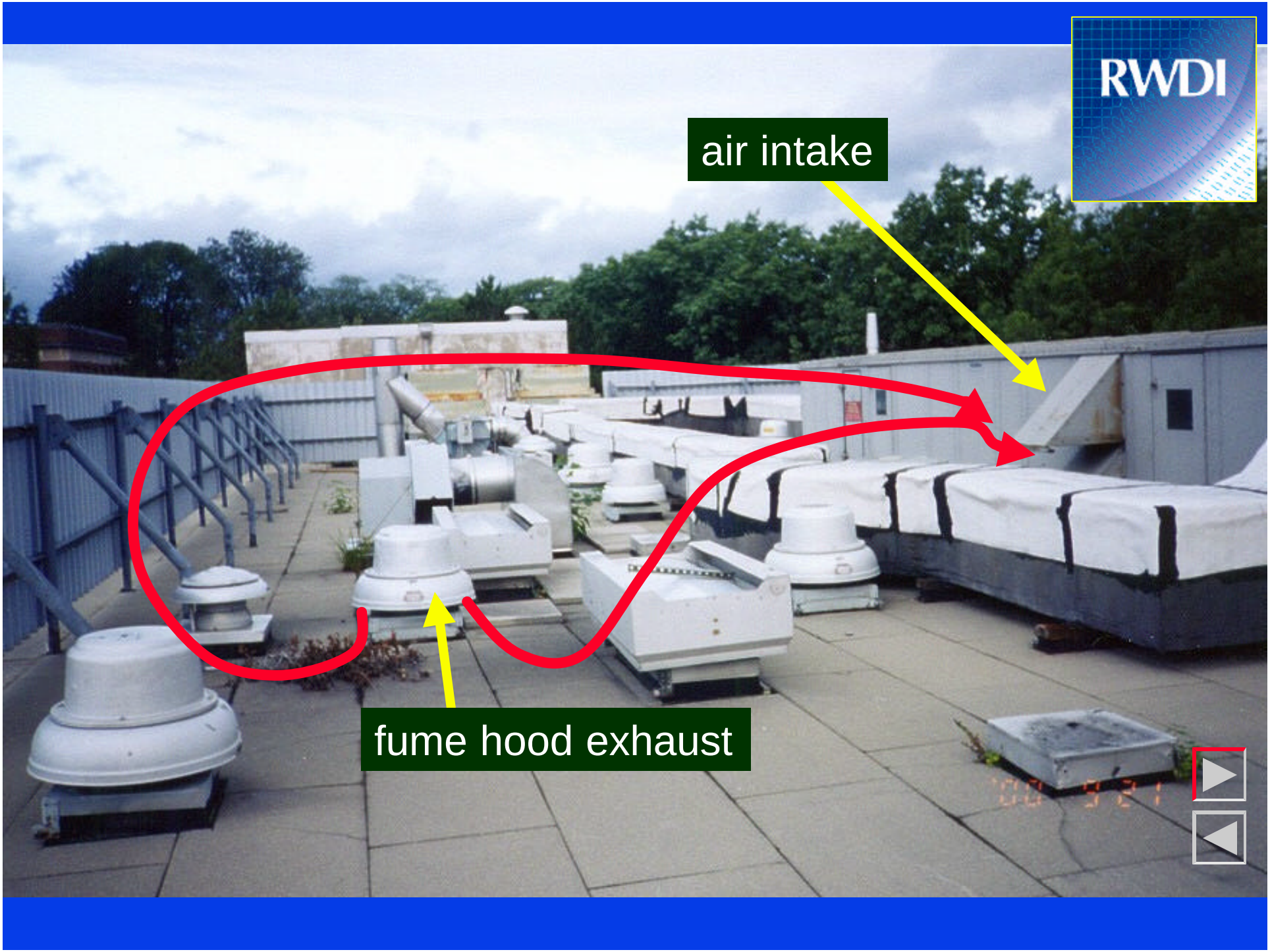
outline

- design challenges
- what is a dilution criterion?
- release scenario
- target dilution

Fume Hood Features




RWDI
air intake
fume hood exhaust

what is dilution?

- Co / Cr

  Co = source concentration

  Cr = concentration at receptor (i.e., intake, pedestrian area, etc)

- example: 100 :1

  99 parts clean air

  1 part contaminated air

criterion

- good stack design
- minimize re-entrainment
- target dilution to meet health and odor thresholds

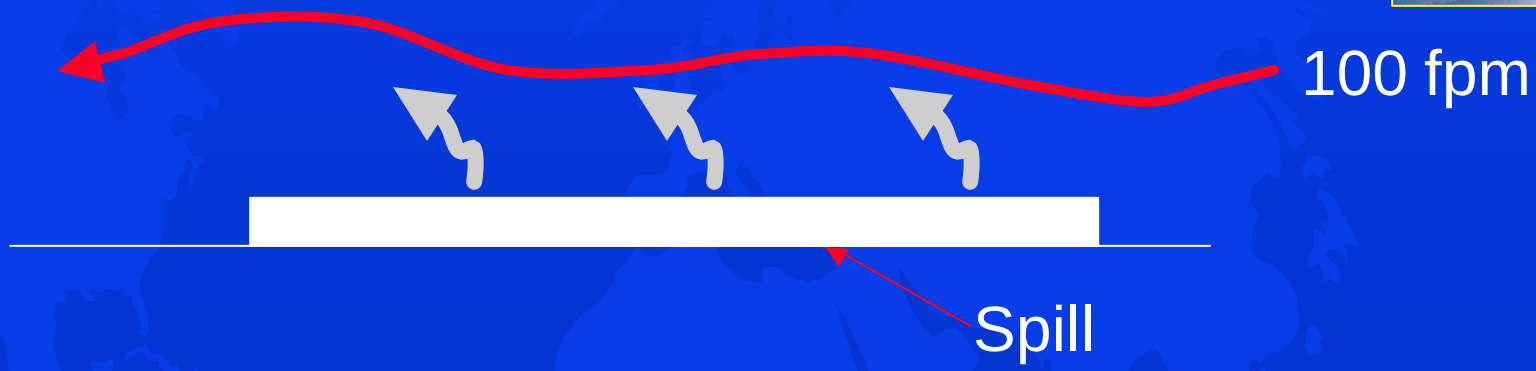
issues with fume hood exhaust design

- high chemical variability
  - physical state,process/activity,volatility
  - unidentified compound
- sustainable design
- emission rates highly variable or unknown

developing a dilution criterion

- release scenario
- list of chemicals
- for each chemical
  - calculated emission rate
  - looked up health/odor limits
  - developed required dilution

liquid emission rate



evaporation calc:
mass transfer relationship

spill area = approx work area = 8.8 ft^2
air velocity = 100 fpm
vapor pressure of liquid at room temp

gas emission rate

- based on release rate of 4 liter/minute
- same emission rate as used in ASHRAE 110 (fume hood testing guideline)
- catastrophic failure perhaps too conservative for design purposes

air quality thresholds

- health limits for occupational exposure to large infrequent emissions
  - ACGIH
  - OSHA
  - NIOSH
- odor thresholds
  - AIHA
  - often more restrictive than health

required dilution

- emission rate with exhaust flow rate
- health and odor thresholds

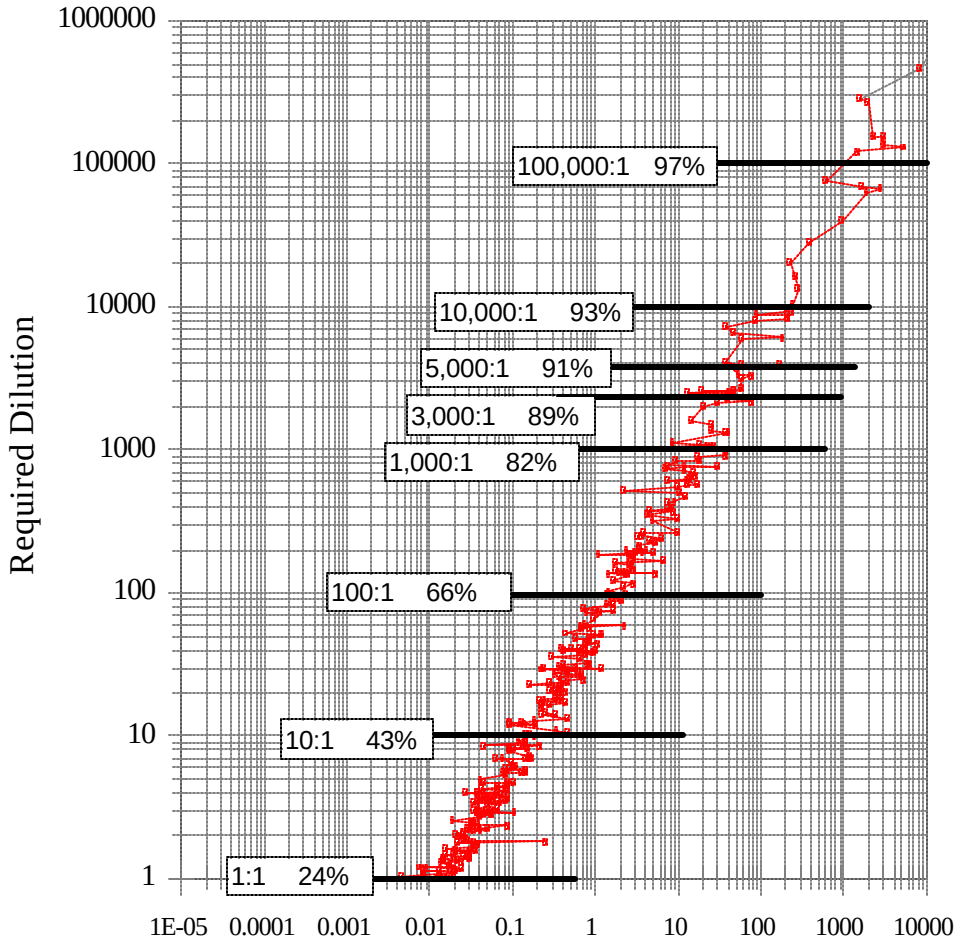
- dilution = $\frac{\text{exhaust concentration}}{\text{allowable concentration}}$

example

- ethyl ether (ether; diethyl ether)
  - vapor press = 59 kPa
  - emission rate = 2.5 g/s
  - exit conc (1000 cfm) = 5.3×10^6 µg/m^3
  - odor threshold = 1700 µg/m^3
- need 3100:1 dilution

Required Dilutions for Liquid Chemical

to prevent both odors and health effects



3000:1

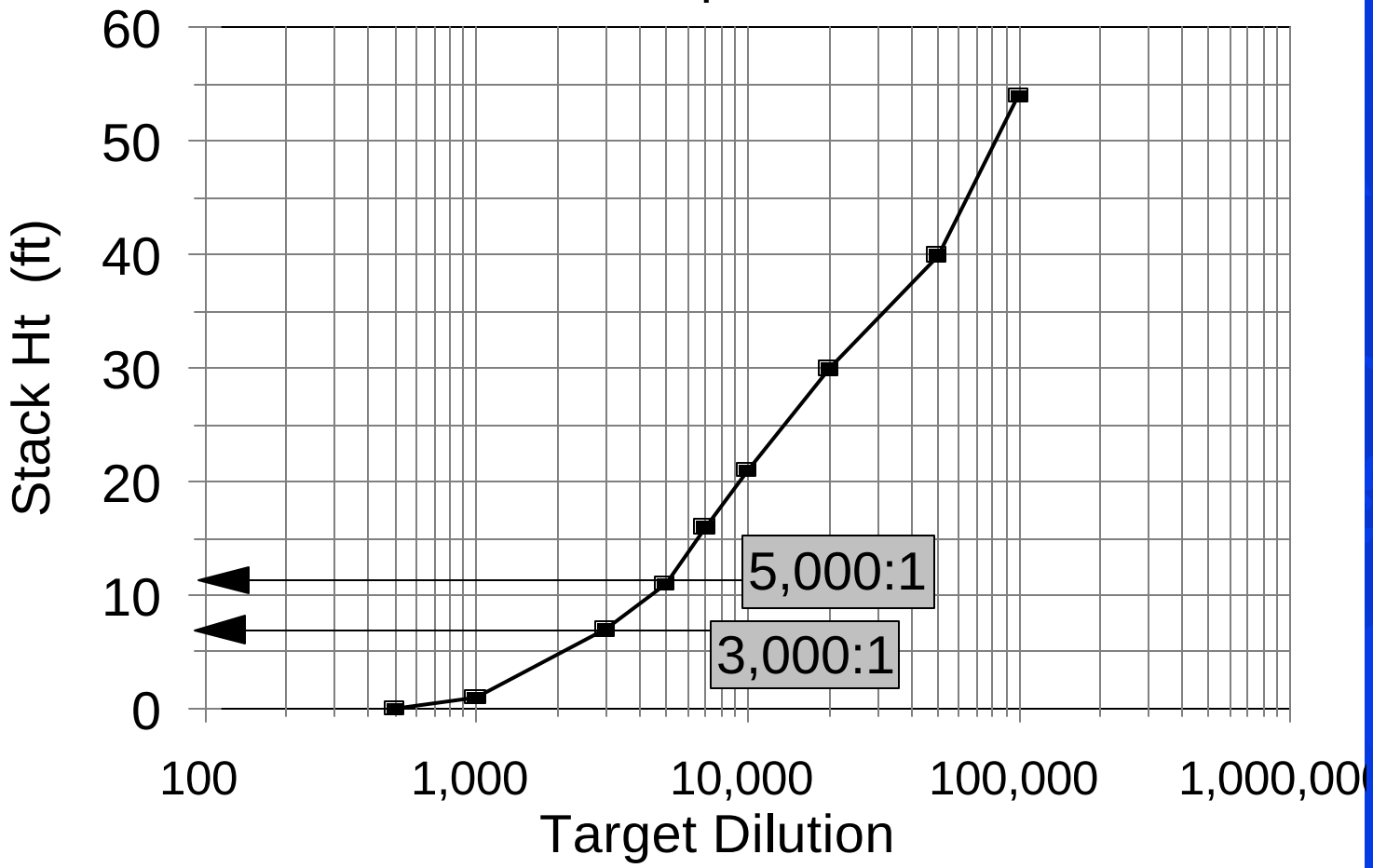
- suggested target
- meets worst case requirements for most chemicals (approximately 90%)
- 0.05 ppm breathing zone concentration
- literature review

3000:1

- successful history (>1000 projects)
- reasonably achievable (feasible stack height)
- can be difficult for single fume hood exhausts

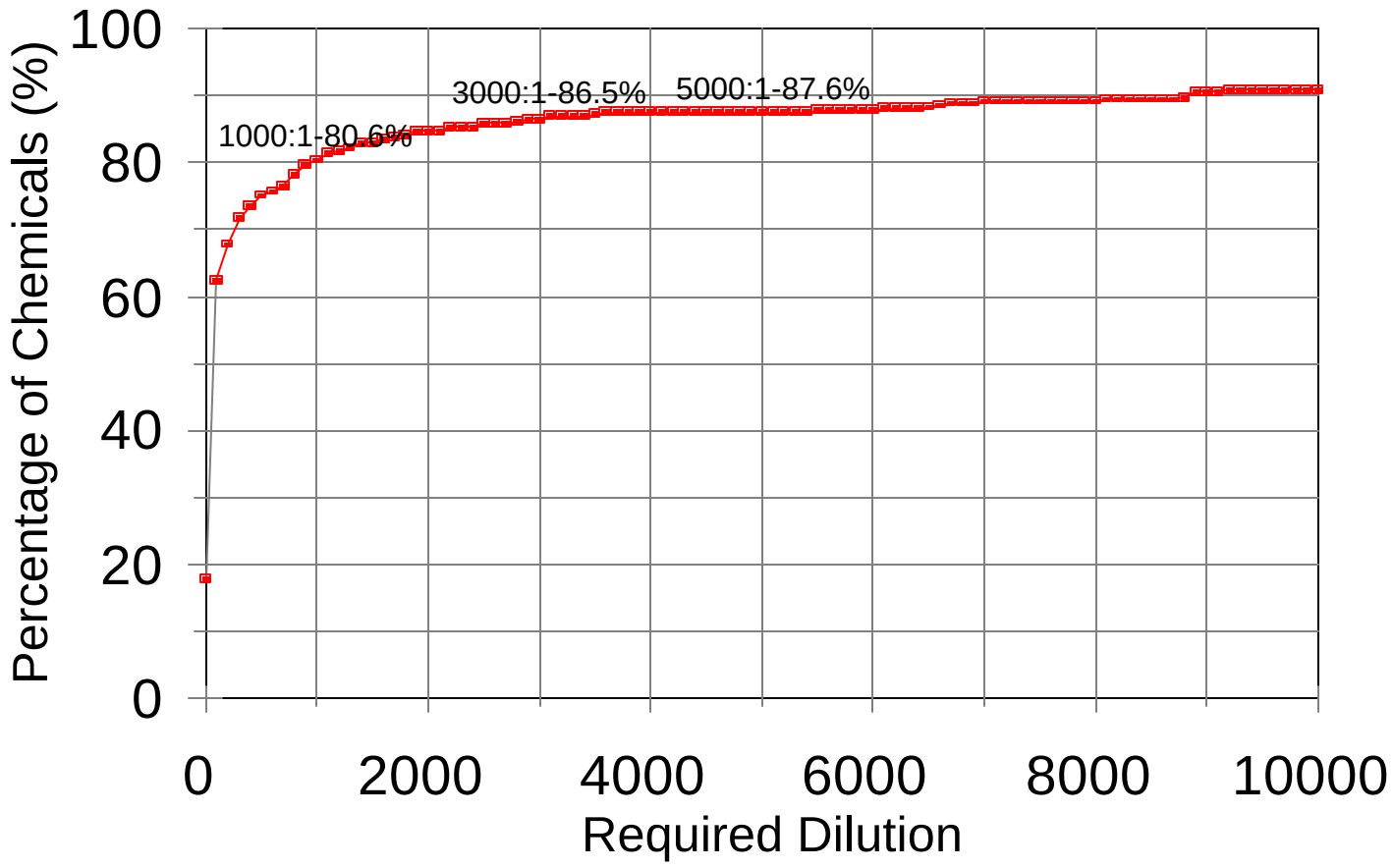
Required Stack Height

10,000 cfm; 3000 fpm exit vel



% of Chemicals vs Required Dilution

Liquids and Gases



internal dilution

- spill scenario considers a spill in one fume hood at any one time
- other fume hood exhausts relatively clean
- 3000:1 referenced to 1000 cfm, typically one fume hood
- flow rates > 1000 cfm, extra air considered “clean”, adds dilution
- example: manifolded fume hood exhausts

internal dilution example

- example:

  total stack exhaust = 30,000 cfm

  clean exhaust = 29,000 cfm

  contaminated air = 1,000 cfm

- call it “30:1 internal dilution”

- 3000 / 30 = 100:1 (required external dilution)

other considerations

- biosafety cabinet
  - light toxic chemical use = reduced dilution criterion
- specific chemicals handled
- handling protocol and procedures
  - limiting spill areas
  - handling volumes

Summary

- general approach to design criterion
  - release scenario
  - 3000:1 relative to 1000 cfm
  - internal dilution is important
  - 3000:1 successfully applied in many cases
  - flexible approach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